GENERAL ELECTRIC

HYDRO-QUEBEC

700-KV TRANSMISSION PROJECT

ELECTRIC UTILITY ENGINEERING

REPORT ON

HYDRO-QUEBEC

700-KV TRANSMISSION PROJECT

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A SYNOPSIS OF THE REPORT ON HYDRO-QUEBEC'S 700-KV TRANSMISSION PROJECT

Voltage.....700/735 kv, 3 phase, 60 cycles

Distance.....1151 miles total - principally in three parallel lines, 356 to 386 miles in length.

MVA Rating.....2500 mw per circuit.

Cost.....Transmission: $400 million
Total: $2 billion

Location.....Province of Quebec - From Outardes and Manicouagan River 6,000,000 HP hydro developments to Montreal area.

Timing.....Manicouagan #2 to Montreal, 1965
Outardes to Montreal, 1966
Complete, 1968

Bid Dates.....Early 1963

700-KV Equipment Requirements (Preliminary Estimate)

1965 Delivery		Total by 1968	
14	Power Circuit Breakers	50?	Power Circuit Breakers
14	Disconnect Switches	50?	Disconnect Switches
3	Shunt Reactor Banks, 1000 mva total	9	Reactor Banks, 3000 mva total
6	Power Autotransformer Banks, 2250 mva total	32	Power Autotransformer Banks, 11,400 mva total
42	Current Transformers	126?	Current Transformers
12	Potential Transformers	36?	Potential Transformers
6 to 9	3-Phase Lightning Arresters	32 to 41	3-Phase Lightning Arresters

General Electric Participation

1. **Full-Scale Tower Test** - Project EHV

   We have been authorized by Hydro-Quebec to proceed with flashover tests of long insulator strings for 700-kv operation. In order to begin supplying data as early as possible, the 500-kv Pacific Gas & Electric tower will be modified for these tests. We have also expressed our willingness to CGE to begin construction of a 700-kv tower just as soon as Hydro-Quebec can provide preliminary dimensions of the proposed tower design.

2. Transient Network Analyzer Study - Schenectady

Customer has inquired regarding our ability to analyze transient and dynamic overvoltages, switching surges, arrester ratings, and location and rating of shunt reactors. We have assured him that we are competent and are presently taking steps to increase our testing equipment where necessary. We believe Hydro-Quebec wants to make this study with us.

Comment

I believe it is essential that we do everything in our power to insure that customer will continue to look to General Electric for solutions in the above two areas of ehv technical capability and in related problem areas which will surely become apparent as the project progresses. It is probable that Hydro-Quebec will energize 700-kv transmission before 500-kv transmission is energized in the United States.

J. W. Yetter, Senior Engineer
Power Transmission Engineering
ELECTRIC UTILITY SYSTEMS ENGINEERING
August 29, 1962

JWY:pms

REPORT ON VISITS TO HYDRO-QUEBEC

At the request of the Canadian General Electric Company, the writer, J. W. Yetter, Power Transmission Engineering, Electric Utility Engineering Operation, visited Montreal on Monday and Tuesday, August 27th and 28th to discuss the capabilities available for the solution of problems relating to ehv transmission and to attend a forum conducted to acquaint manufacturers with the 700-KV Transmission Project of the Quebec Hydro-Electric Commission, more popularly known under its bilingual registration as Hydro-Quebec.

Monday afternoon and evening were spent in discussion of the information known about the Project as well as preparation for a private meeting with System Planning to be held on Tuesday morning. The following participated in these discussions:

Name	Representing
R. A. Blount	Electric Utility Sales - CGE, Montreal
H. M. Shockley	Power Systems Sales - CGE, Peterborough
C. M. Stairs	Power System Engineering - CGE, Peterborough
V. B. Ross	Transformers, Reactors, L.A.'s - CGE, Guelph
G. E. Drew	Switchgear - CGE, Peterborough
J. W. Yetter	EUEO - GE, Schenectady

Preceding the meeting on Tuesday morning, the above met with Mr. A. Stevinson, Manager of Electric Utility Sales, Montreal, and Mr. Howard Lucas, Davenport Works, representing CGE's interest in instrument transformers. All of the above, with the exception of Mr. Blount, proceeded to Hydro-Quebec where we met with Mr. J. R. Hango, System Planning Engineer and Mr. Jacques Archambault.

TUESDAY MORNING MEETING:

Mr. Hango opened with a brief description of the 700-KV Project and an inquiry regarding the technical services which CGE/GE might provide.

He expressed particular interest in proceeding with a transient analyzer study as quickly as possible. Most of the morning discussion was concerned with the transient study.

It appeared to several of us that Mr. Hango and Mr. Archambault had decided in advance that transient study was absolutely necessary, and that they had a distinct preference that this study be performed on the Schenectady Transient Network Analyzer. They appeared to doubt the accuracy of the Westinghouse representation of the nonlinear characteristics of transformer cores. Many detail questions were asked with respect to placing and sizing of shunt reactors, determination of arrester ratings, etc. It is my opinion that they were testing our comprehension of the problem and that they were satisfied with the answers given.

Mr. Hango then asked us how long we would need to complete a TNA study, and how soon we would be able to begin. I suggested that four or five weeks might be required, and that I would report back through CGE on scheduling as soon as possible following my return to Schenectady on August 29.

There was some discussion of our digital load flow studies with Hydro-Quebec. They would prefer more work on the IBM-7090 from the cost point-of-view. We had learned outside of this meeting that they are interested in IBM-7090 studies offered by a Boston consulting firm.

Some interest was expressed in other areas of CGE/GE ehv capability, and these were briefly described.

The meeting terminated at approximately 11:20 a.m. to permit Messrs. Hango and Archambault to attend a special meeting called by Mr. Haberl prior to the EHV Forum scheduled for 2 p.m.

700-KV FORUM - TUESDAY AFTERNOON

Mr. H. W. Haberl, Assistant Chief Engineer, had invited representatives from all the major North American and European manufacturers of transmission terminal apparatus to attend a forum announcing the plans for the 700-KV Transmission Project of Hydro-Quebec (see Exhibit "A", letter of invitation, attached).

Mr. Haberl opened the meeting by introducing the newly-formed:

EHV PROJECT GROUP -- HYDRO-QUEBEC

H. W. Haberl, Chairman, Assistant Chief Engineer

J. R. Hango, System Planning Engineer

A. T. Farmer, Consultant on Transmission

L. D'Auteuil, Apparatus Engineer

G. Monty, Transmission Engineer

J. J. Archambault, Assistant System Planning Engineer,

(PSEC 1953-54, Member GE Project EHV

Advisory Council)

L. Cahill, (not present--taking Business Administration at

Harvard)

He stated that this meeting had called together the vendors of Europe and North America to advise them of the details of the 700-KV Project, and to ask them,

"What can you do?"

"Why can you do it?"

"When can you do it?"

He announced that a firm decision has been made to proceed with 700/735-kv, three-phase, 60-cycle transmission of approximately 5000 mw from 6-million horsepower hydro developments on the Manicouagan (abbr. "Manic"), and

Outardes Rivers to the Montreal area, a distance of slightly over 350 miles. The decision to proceed at 700-kv nominal operating voltage was based on the belief that it could be done with three lines without series capacitors or switched shunt reactors for no more cost than 500 kv, which would have required four lines, 70% series compensation, and switched reactors.

Slides were shown of the 4000-man construction camp in operation at Manic #5, 135 miles north of the Baie-Comeau area, and of the Manic #2 site. Manic #5 dam will be 750 feet high, and will flood a storage reservoir of 5000 billion cubic feet, approximately eight times the impoundment behind Hoover Dam.

A basic single-line diagram was distributed (Drawing SP3-585, dated August 24, 1962, Exhibit "B" attached). This drawing shows 300-kv "collector stations" at locations near Manic #2 and Outardes #4, supplying three lines of 356 to 386 miles in length, and having intermediate switching stations near Quebec City, 226 miles from the collector stations. Energy will be delivered to 300-kv receiving systems, principally in the Montreal area.

It was pointed out that transformers were sized at three-phase bank capacities not exceeding 450 mva on the belief that 150-mva, single-phase units would be the maximum that any manufacturer could ship to the collector stations. There is no system limitation. Sizes can be adjusted to accommodate the total kva shown on the diagram.

Shunt reactors shown are total kva required based on Hydro-Quebec's estimate that 70% shunt compensation of the lines' capacitive generation will give satisfactory performance. It is hoped that shunt reactors will

not be required in the Montreal receiving area, and that switched reactors will not be required on any transformer tertiaries.

It was stressed many times during the meeting that the maximum 60-cycle operating voltage would not exceed 735 kv.

Discussion of the transmission line characteristics was not solicited at this meeting which was concerned only with terminal apparatus requirements.

Transformer BIL will be determined by the characteristics of available arresters, which must be capable of discharging the trapped energy of at least 226 miles of line energized at 735 kv. Particular interest was expressed in determining what manufacturer could supply such an arrester. No manufacturer commented.

Reactors will be connected on line side terminals of breakers and will be switched on and off with the line. Mr. Haberl commented that arresters might be required on these terminals as well as the terminals of the transformers.

No tap-changing-underload equipment will be specified on transformers.

No preference will be specified for or against auto-connections of the transformer windings.

Mr. Haberl stated that transformers probably should have "some tertiary" but that tertiary loading is not planned. The system will be designed for "some automatic reclosing", but it will not be depended upon for firm power transfer. Consequently, each 700-kv circuit must be capable of 2500-mw transmission to permit 5000-mw of firm capacity with one circuit out of service at peak load.

Interest was expressed in any device or accessory which might be used to reduce the magnitude of switching surge voltage during breaker operation.

The total development is expected to cost approximately $2 billion, including transmission and terminal apparatus at $400 million.

Manufacturers were asked to make recommendations for terminal apparatus insulation level, and to state what apparatus they will be able to supply, together with delivery schedules. They were asked to give reasons, backed by data, why they feel they are in a position to provide equipment. Answers were requested within 30 days to permit Hydro-Quebec to prepare performance specifications for firm tender early in 1963. Equipment will be purchased with guaranteed delivery as is their custom. It was acknowledged that they could be forced to 300-kv operation in the initial phase (1965), but 700-kv will be required in 1966, and the project is scheduled for completion in 1968.

The following estimate of equipment requirements is to be considered preliminary and subject to correction. CGE personnel are already working to improve this estimate where data given at the meeting do not seem to agree with the drawing.

700-KV Equipment Requirements (Preliminary Estimate):

1965 Delivery		Total by 1968	
14	Power Circuit Breakers	50?	Power Circuit Breakers
14	Disconnect Switches	50?	Disconnect Switches
3	Shunt Reactor Banks, 1000 mva total	9	Reactor Banks, 3000 mva total
6	Power Autotransformer Banks, 2250 mva total	32	Power Autotransformer Banks, 11,400 mva total
42	Current Transformers	126?	Current Transformers
12	Potential Transformers	36?	Potential Transformers
6 to 9	3-Phase Lightning Arresters	32 to 41	3-Phase Lightning Arresters

Some shunt capacitors may be used for receiving system voltage control, but will not be considered as a part of the EHV Transmission Project. Power line carrier current relaying may be used, and microwave might be considered pending outcome of tests about to be made on a part of the 300-kv system.

Following this general briefing, Mr. Haberl asked the Montreal representative of ASEA,

Question: "Mr. Jensen, is your Company ready to deliver all components?"

Answer: "Most certainly."

At this point, questions were solicited from the assembled manufacturers. Some of them are recorded below:

Question: "Will the system neutral be grounded?"

Answer: "Absolutely - without resistance or reactance."

Question: "What is the heaviest piece that can be transported?"

Answer: "Possibly 100 tons. 75-ton bridge limits can probably be exceeded with shoring. No rail facilities exist beyond the Saguenay River. (Both collector stations are beyond the Saguenay.) It may be necessary to build a "transformer factory" for assembly and test of transformers."

Question: "Are there height limitations for shipment?"

Answer: "30 feet to 161-kv line."

Question: "Would you consider solid porcelain-type insulators?"

Answer: "Yes, but not seriously. This is moose country. (Rifle damage.)"

Question: "Have you a radio noise level in mind?"

Answer: "For the line, the tolerable limits set by CSA Standards for microvolts at mid-span at the edge of the right-of-way will apply. We will probably establish test limits for apparatus RI."

Question: "Have you decided on conductor bundles?"

Answer: "Four- or three-conductor bundle. Don't concern yourself-- we (Hydro-Quebec) will decide."

Question: "What will be the surge impedance?"

Answer: "275 ohms" (Archambault)

Question: (Westinghouse) "Would you consider reducing the 300-kv insulation level below your present standard of 1050 kv?"

Answer: "Probably just the reverse. Possibly higher than 1050-kv BIL on the 300-kv side unless you convince us that you can protect a lower level on the autotransformer."

The formal part of the meeting was closed by Mr. J. C. Lessard, Chairman of the Commission. He thanked manufacturers for coming and reiterated that this is a firm decision. "Hydro-Quebec is certainly going ahead with 700 kv."

J. W. Yetter

Prepared by: J. W. Yetter, Senior Engineer
Power Transmission Engineering
ELECTRIC UTILITY SYSTEMS ENGINEERING

August 29, 1962

COPY EXHIBIT "A" COPY

QUEBEC HYDRO-ELECTRIC COMMISSION
75 DORCHESTER BOULEVARD WEST
MONTREAL

22nd August, 1962

Canadian General Electric Co.,
1010 Beaver Hall Hill,
Montreal, Que.

Attention: Mr. C. A. Morrison,
Commercial Vice-President

Dear Sir,

Re: Extra High Voltage - Manicouagan System

The Commission has confirmed the Engineering Department's recommendation that the transmission system westward from the Manicouagan generating plants be nominally 700 kv. The Engineering Design Division are in hopes that they can produce performance and general specifications for station equipment which will be available for the calling of public tenders early in 1963, for delivery starting early in 1965. The ultimate and final requirement for all apparatus will probably be 1968.

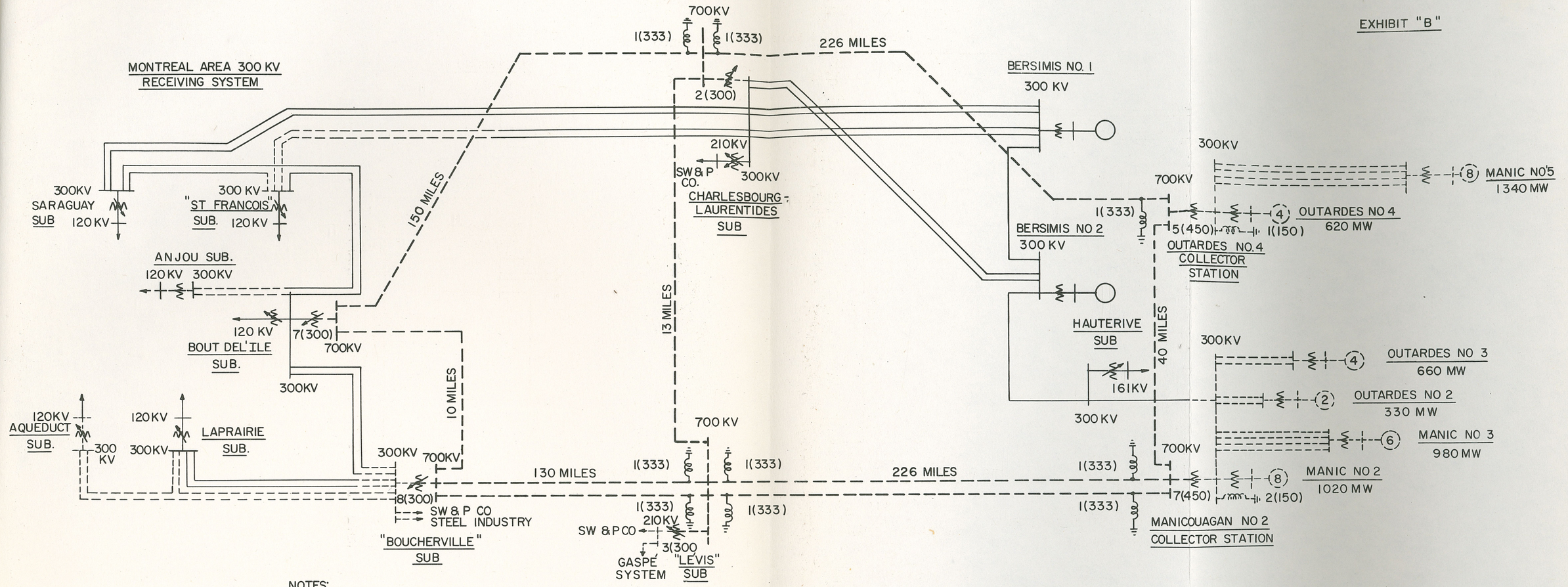
In order to acquaint your company with a rough idea of the magnitude of the job and types of equipment required, we are asking you to attend a forum in the Auditorium on the Mezzanine Floor of the Hydro Quebec Building on Tuesday, August 28th at exactly 2 p.m. Following the meeting and your report to your principals, we would be pleased to receive from you reasons backed by data as to why and how your particular company feels they are in a position to design, manufacture and deliver the related items in the prescribed time. The Hydro Quebec engineers will summarize the reports received from your company and these reports, together with technical data supplied, will form the basis of the performance specifications. In other words, we do not feel that we should arbitrarily write such specifications on an impossible device, an impossible design, or an impossible delivery.

Yours very truly,

H. W. Haberl,
Ass't Chief Engineer,
Engineering Design Division

HWH/sbh

EXHIBIT "B"



NOTES:

1 - EXISTING 300KV SYSTEM SHOWN BY SOLID LINES PROPOSED FUTURE ADDITIONS @ 300 KV AND 700KV SHOWN BY BROKEN LINES

2 - SUBSTATION EQUIPMENT DETAILS SUCH AS CIRCUIT BREAKERS, DISCONNECTS, LIGHTING ARRESTERS, ETC AND CONNECTION DETAILS NOT SHOWN

3 - TENTATIVE NUMBER AND MVA OF TRANSFORMER BANKS AND REACTOR BANKS SHOWN THUS: 7(450) SUBJECT TO CHANGE AFTER FURTHER STUDY.

4 - VOLTAGE SHOWN ON MAIN BUSSES ARE NOMINAL VALUES

5 - 1-700 KV LINE AND ASSOCIATED EQUIPMENT IF AVAILABLE PLANNED FOR SERVICE IN 1965. COMPLETE 700KV SYSTEM MAY BE REQUIRED 1968 TO 1970

COPIED BY - G. Tulus
PREPARED BY:
DRAWN BY L. MAINVILLE..
CHECKED BY:
DATE: AUGUST 24, 1962

HYDRO-QUÉBEC

SYSTEM PLANING BRANCH

BASIC SINGLE LINE DIAGRAM OF 700 KV TRANSMISSION SYSTEM FROM FUTURE MANICOUAGAN & OUTARDES GENERATIONS STATIONS TO QUÉBEC AND MONTRÉAL UNDER STUDY

DWG NO SP3-585